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ABSTRACT

This study examined the effects of feedback (immediate, delayed, or no feedback) and the type of control (external or internal) on computer-assisted instruction (CAI), and also considered the influence on achievement of such factors as computer anxiety, self-concept, learning style, and gender. Subjects were 336 undergraduates, the majority of whom had never taken a computer course, and the CAI material taught objectives for a college-level course in research. The data showed no significant difference in achievement for either the control or feedback variables. However, female students were found to be more computerphobic than males and less likely to have taken a computer course, but neither difference correlated with achievement scores; in fact, the female students achieved significantly higher scores. It was also determined that students who had taken a computer course had more positive self-concepts than students who had not. In addition, female students were found to have a more concrete learning style, and they were less reflective in their style of learning. Further, internal-control students who chose to select branches to work through had higher achievement scores than students who did not branch as frequently. The text is supplemented by 3 tables and 45 references. (EW)

The Effects of Selected CAI Design Strategies on Achievement, and an Exploration of Other Related Factors

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The Effects of Selected CAI Design Strategies on Achievement: and an Exploration of Other Related Factors

Researchers have demonstrated that programmed instruction methods, using both computer and print technologies, can increase learning in many content areas and populations (Hannafin, 1985). It is apparent that good computer programs help learners learn. However, researchers must isolate variables systematically, and examine their effectiveness, in order to improve the design of computer-assisted instruction. The CAI design strategies under investigation in this study were type of control (internal vs. external) and feedback (immediate vs. delayed vs. no feedback). In internally controlled CAI programs, the option to select a branch is decided by the person using the program. In externally controlled programs, branches are selected for the learner, based on responses to embedded questions.

In addition, educators have speculated that personality characteristics can either interfere with or enhance learning by computers (Eisele, 1984). For example, Maurer and Simonson (1984) contended that computer anxiety can interfere with computer-based learning. Thus, the purpose of this study is not only to determine the effects of type of control and feedback on learning acquisition, but also to explore the influence of such factors as computer anxiety, self-concept, learning style, and gender on achievement, as well as to study how these factors correlate with each other.

Hazen (1985) declared that both learner control over CAI choices and non-threatening, positive feedback can keep learners motivated when working through CAI programs. The question is do these strategies aid learning?

Control Strategies

One of the more interesting issues in the area of computer-assisted instruction is the control of the instruction and where it should be placed. Internal-control strategies put the learner in charge of the instruction. External control allows some interaction between the instructional program and the learner, but ultimately the program determines the "path" through the instruction.

Research has been conducted which compares the effectiveness of internal-control strategies to external-control strategies. Sasscer and Moore (1984) asserted that "the research literature related to learner control of instruction is characterized by reports of contradictory findings and equivocal terminology" (p. 28).

Since learner control usually means that the individual is allowed to select options for additional or enhanced instruction, the research by Tobias (1984) has important implications. Treatments in Tobias' study offered students a choice of internal or external control. Findings suggested that even if students' selection of options was "frequently not wise or informed the mere selection of a control strategy increased cognitive processing and thus achievement was increased" (p. 8). When learner control and external control were more directly compared by Laurillard (1984), the conclusion was that students elect to branch when given that option and in such a variety of ways

that "program control must seriously constrain the individual preferences of students" (p. 14). Additional research by Stevens (1984) suggested that greater amounts of learner control increased learning.

In contrast to research findings which favor the use of internal-control strategies, there is evidence that external control may better serve learners' needs. Belland, Taylor, Canelos, Dwyer and Baker (1985) found that external pacing resulted in somewhat higher achievement than internal pacing. These findings were confirmed in studies by Dwyer, Taylor, Canelos, Belland and Baker (1985) and Canelos, Baker, Taylor, Belland and Dwyer (1985). These findings support much earlier research by McLaughlin and Malaby (1974). When students were permitted to work through units at their own pace, they completed fewer units than did students who were directed to complete a specific number of units per day.

Some support also has surfaced for an approach which advises the student about branching decisions. However, this is almost a form of external control, since the computer program does influence decisions. Research by Tennyson and Buttrey (1980) and Tennyson, Tennyson and Rothen (1980) found this adaptive or advisement strategy to be superior to both external and internal control in computerized instruction.

Research also exists that shows conflicting results for type of control strategy. As early as 1979, Mabee, Neimann and Lipton discovered no significant differences between self-paced (internal control) and instructor-paced (external control) learning. More recently, Goetzfried and Hannafin (1985a, 1985b) found no significant differences between groups utilizing internal-control, external-control and linear (no control) CAI programs. This supported the earlier non-significant findings of Dunn (1971), who examined review strategies which were either internally or externally controlled. One reason for the lack of significant differences in these studies was suggested by Garhart and Hannafin (1986), who concluded "that learners are not good judges of their en route comprehension" (p. 12).

Feedback

For most of this century, it has been stated that frequently administered feedback aids learning (Pressey, 1926; Skinner, 1954). However, many researchers have found that knowledge of results and reviews have not had a significant effect on learning acquisition (Cohen, 1985; Dunn, 1971; Gilman, 1969), although other studies have found certain feedback strategies to be effective (Kulhavy, 1977; Tennyson & Buttrey, 1980). For example, Gilman (1969) reported that varying how content was presented worked better than did repetition to improve learning, after incorrect responses were made.

Sassenrath (1975) reported that delayed feedback was superior to immediate feedback generally, although Joseph and Maguire (1982) expressed doubt about the effectiveness of delayed over immediate feedback, after studying this variable in a variety of learning situations. Furthermore, when Hodes (1984-1985) compared the effects on learning of corrective feedback (i.e., encouraging

students to make further attempts to give the right answer) and noncorrective feedback (i.e., not encouraging and even discouraging students to make the correct response), no statistically significant differences were found.

Individual Difference Variables

Computerphobia has been defined as the resistence to the subject of computers and avoidance of them, as well as fear, anxiety or hostility towards computers (Jay, 1981; Maurer & Simonson, 1984). This condition generally manifests itself in the form of negative statements about computers and their use (Maurer & Simonson, 1984). Researchers have demonstrated that people who have had some experience using computers have more positive attitudes towards them than do inexperienced people (Kulik, Bangert & Williams, 1983; Loyd & Gressard, 1984; Tyagi, 1984). Jonassen (1986), however, found that no relationship existed between level of computer experience and state anxiety when using a computer.

According to Mercant and Sullivan (1983) and Winkle and Matthews (1982), females had less favorable attitudes towards computers than did males, as well as higher levels of computer anxiety. Although both negative attitudes and high anxiety can have deleterious effects on learning, neither of these relationships has been investigated thoroughly. Furthermore, it has not been demonstrated conclusively that males have significantly better attitudes towards computers than do females. In fact, Loyd and Gressard (1984) and Swadener and Hannafin (1987) found no significant differences statistically when investigating gender differences and attitudes towards computers.

There is some evidence to suggest that a positive correlation between high self-concept and academic achievement, in general, exists (Green, 1977). However, the relationship between self-concept and learning from CAI programs has not been thoroughly explored. Although both low- and high-achieving learners can benefit from CAI, it has not been shown that self-esteem can be improved significantly by CAI (Dalton & Hannafin, 1984), or even that those with good self-concepts learn better from CAI programs.

Recent interest in researching individual differences is an encouraging sign for education. Hoffman and Waters (1982) stated that CAI is best for individuals "who have the ability to quietly concentrate, are able to pay attention to details, have an affinity for memorizing facts, and can stay with a single task until completion" (p. 51). Smith (1985) found that visually perceptive students achieved better in a CAI presented learning task than did the nonvisually perceptive. Hedberg and McNamara (1985) found "that the interaction of feedback with cognitive style did not improve the performance of field independent subjects" (p. 14). In fact, field independent subjects were negatively influenced by feedback. Hannafin (1985) suggested that learners whose locus of control was internal made more accurate and effective instructional-control decisions than learners whose locus of control was external.

Learning style has been defined in a number of ways, which include the learner's preferences for a number of instructional techniques (Ristow & Edeburn, 1983). However, as pointed out by Enochs (1985), learning style

generally is concerned with an individual's preferences for learning abstractions or more concrete information. They found that concrete learners learned more from CAI than did more abstract learners. Kolb and Baker (1984) separated learning styles into two continuums: (1) the Active Experimentation, Reflective Observation continuum, and (2) the Concrete Experience, Abstract Conceptualization continuum. It is perhaps these learning styles which may prove to increase our knowledge of how individual differences interact with instructional techniques.

Methodology

Three hundred thirty-six undergraduate students from speech, communications and psychology were assigned randomly to one of seven groups. There were more females (60%) than males (40%) included in this sample, and the majority (60%) had never taken a computer course. Each of the CAI treatments was designed to include one or more of the independent variables under investigation.

The content of the CAI programs used in this study taught objectives for a college-level course in research. The content dealt with definitions and concepts in social-science research, including defining, stating the purposes of and discriminating among descriptive, experimental and historical research; dependent and independent variables; surveys and questionnaires; and types of sources.

The seven treatments can be described as follows:

1. Linear program. There were no embedded questions and therefore no feedback. No options were offered to the subjects and therefore no interaction took place. Students read each screen, pressed the return key and read the next screen until they were finished.

2. External control with no feedback. Subjects were asked questions about the content at certain points in the instruction. If they answered the question incorrectly, they were recycled through the instruction and asked the question again. This group saw all the screens that would eventually become options for the internal-control group.

3. External control with immediate feedback. Conditions were the same as for treatment #2, with immediate feedback given for responses to questions. Feedback screens appeared immediately after subject's responses.

4. External control with delayed feedback. Conditions were the same as for treatment #2, with delayed feedback given for responses to embedded questions. Once the subjects completed the CAI program, they were given feedback regarding the number of correct responses they had made before taking the post test.

5. Internal control with no feedback. Subjects were asked questions at certain points in the instruction before they were offered the opportunity to see additional instruction or to review what they

had just seen. Upon answering a question, they had the chance to continue or to go back and see the instruction again if they answered the previous question incorrectly.

6. Internal control with immediate feedback. Conditions were the same as for treatment #5, with immediate feedback included.

7. Internal control with delayed feedback. Conditions were the same as for treatment #5, with delayed feedback given.

The seven treatments were assigned randomly to the seven groups.

Data collection was conducted in two sessions. The first session introduced subjects to the purpose of the research and a number of tests and questionnaires, which represented a number of additional variables, were administered.

The first of these variables was computerphobia, measured via a Likert-type attitude scale developed by Maurer and Simonson (1984). The second variable was self-concept, as measured by the Tennessee Self-Concept Scale (Fitts, 1964). An overall self-esteem score was determined (i.e., Total P Score). The third variable was learning style, which was measured by the McBer and Company Learning Style Inventory, developed by Kolb and Baker (1984). Finally, a short demographic questionnaire was administered. All data on additional variables were collected in sessions attended by 30 to 70 subjects.

The second data-collection session was scheduled to take place in a microcomputer laboratory with each subject, who had to work individually. The subject was given the CAI program assigned to his/her group, worked through the program, and then took a post-test. This dependent measure was a 15-item, multiple-choice test, which was designed to measure learning from the CAI programs. The number of branches that each subject elected to take was recorded by the computer.

A 2x3 completely randomized factorial design, with fixed effects, with a control group was used in this study. The independent variable, Control, had two levels: (1) active, voluntary, internal control, and (2) passive, forced, external control. The other independent variable, Feedback, had three levels: (1) immediate, (2) delayed, and (3) no feedback. The control group received a linear program, with no feedback given. Data were analyzed using ANOVA techniques for main effects and interactions, as well as Tukey-HSD and correlational procedures.

Results

Both the within-cell and treatment-level means for the achievement measure, as well as the number of subjects under each condition, are shown in Table 1. The analysis of variance results are displayed in Table 2. No significant differences between means were found for either the control or feedback independent variable. It should be noted that the linear, no-feedback control group was excluded from these analyses. However, when Tukey's HSD test was

employed to make all pairwise comparisons among the levels of the independent variables, the mean of the control group was included. Although the control group scored most poorly, Tukey's HSD procedure indicated that no two groups were significantly different at the .05 level.

An investigation of the relationship among various personality and demographic variables, number of branches taken by internal control subjects, and achievement scores revealed a number of interesting findings. The results of the correlational analyses appear in Table 3.

Female students were found to be significantly more computerphobic than were males (r = .10) and not to have taken a computer course (r = .21). However, neither higher computerphobia nor lack of computer coursework were correlated with achievement scores. Furthermore, female students achieved significantly higher scores than did the males in the study (r = .10). It also was determined that students who had taken a computer course had more positive self-concepts than those who had not (r = .14).

In addition, females were found to have a more concrete learning style (r = .13), but were less reflective in their style of learning (r = -.10), than males. It was discovered that concrete learners were more computerphobic (r = .13). Furthermore, internal-control subjects who chose to select branches to work through had higher achievement scores than did students who did not branch as frequently (r = .33).

Discussion

Findings of no significant difference necessitate caution in drawing conclusions. No differences were uncovered for the main independent variables, Control or Feedback. With the simple, verbal-information learning task employed in this study, subjects seemed to be able to learn regardless of control strategy or method of feedback. The lack of significant findings for the independent variables can be attributed to two possible reasons. First, the great care taken to design seven effective CAI programs may have resulted in the development of instructional programs that failed to maximize experimental differences. Second, the simplicity of the learning task for these subjects may have led to a failure to show differences among treatment levels. However, findings of no significant difference are common in CAI research, such as in the study by Dalton and Hannafin (1984).

A number of additional conclusions were drawn based on data analysis. Subjects who chose to branch received information that allowed them to score higher on the achievement test than those who elected not to branch as frequently. Although females scored higher on the computerphobia scale, this did not interfere with their performance on an achievement test, after they worked through a CAI program. Could it be that the traditional differences between genders on such subjects as mathematics and computers is no longer a major factor? More concrete learners had higher computerphobia scores. Is the activity of sitting at a computer keyboard likely to raise anxiety among such learners? There may be a need for more research in such areas as the relationship of various learning styles to learning from CAI and other electronic learning aids.

More research needs to be conducted on how different types of individuals learn from microcomputer, and about how to make computer software more effective enhancers of learning. Microcomputers are rapidly becoming one of the most important media of instruction in our schools and in business and industry. Educators and trainers must be able to determine the best ways to use microcomputers. Learning achievement and efficiency can be increased possibly by the right combination of control and feedback strategies. With this in mind, a number of recommendations are offered.

1. This study should be replicated with different levels of learning tasks.

2. Different populations should be used in a replication of this study.

3. An examination of other possible correlational variables, or variables which represent other areas of individuals differences (such as locus of control and cognitive style), should be conducted.

4. A meta analysis of CAI research should be conducted to bring together all findings to date and lead to more recommendations for designing better programs.

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Table 1

Achievement Means and Subject Frequencies for Control and Feedback Factors in CAI Programs

Control	Feedback			
	Immediate	Delayed	No	
Internal	13.19 (16)	12.56 (18)	13.15 (13)	12.94 (47)
External	12.40 (40)	12.83 (47)	12.76 (45)	12.67 (132)
	12.63 (56)	12.75 (65)	12.84 (58)	

Note: The number of subjects in each experimental unit is in parentheses.

All internal-control subjects who branched fewer than 15 times were excluded from this analysis.

The Linear, No-Feedback Group had a mean of 12.26 and had 42 subjects.

Table 2

Analysis of Variance on Achievement Scores for Control and Feedback in CAI Programs

Source of Variation	df	MS	F
Control	1	2.59	.93
Feedback	2	.80	.29
Control x Feedback	2	3.54	1.27
Residual	173	2.78	

Table 3

Correlations Among Personality and Demographic Factors, Branching, and Achievement Scores

Factor	Achievement	Computer Course	Computer-phobia	Gender
Gender	.10*	.21***	.21***	
Computerphobia	.03	.16**		
Self-Concept	.04	.14**	-.06	.08
Learning Style (Concrete Experience)	.09	-.04	.13**	.13*
Learning Style (Reflective Observation)	-.07	.07	-.04	-.10*
Learning Style (Abstract Conceptualization)	.03	.00	-.05	-.08
Learning Style (Active Experimentation)	-.02	.00	-.05	.02
Branching	.33***	.09	.04	.07
Computer Course	-.09			

*$p<.05$ **$p<.01$ ***$p<.001$

Note: Number of cases ranged from 276 to 329 for all correlations, except for those involving branching (with data from 115 to 125 subjects analyzed).